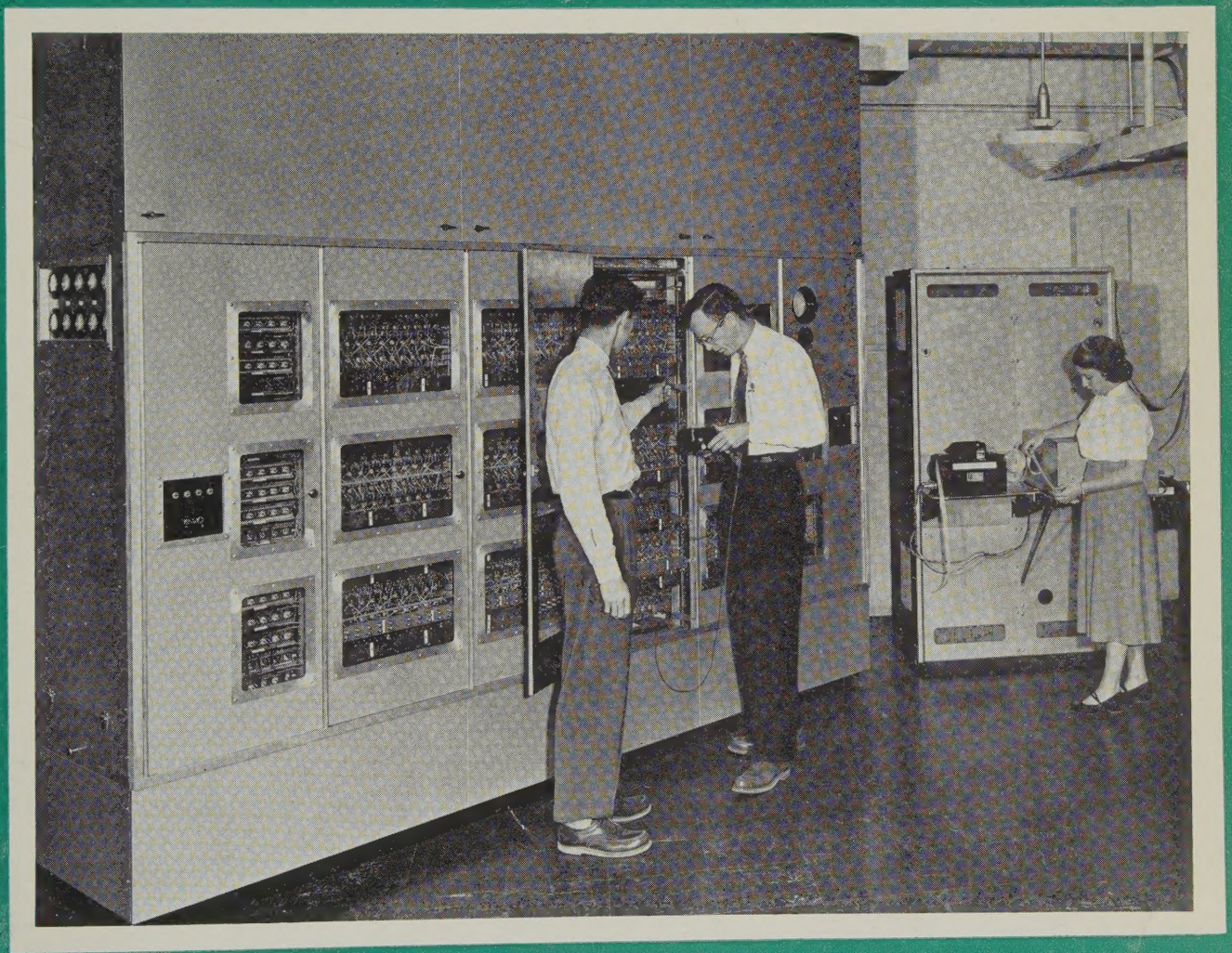
SOCIETY OF ILLINOIS PROFESSIONAL ENGINEERS
FOUNDED 1886

the ILLINOIS ENGINEER

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS
FOUNDED 1934

Typical Questions Professional Engineer Examination



"ILLIAC," ELECTRONIC COMPUTER AT THE UNIVERSITY OF ILLINOIS

THE ILLINOIS ENGINEER, OCTOBER, 1955—VOLUME XXXI, NO. 10

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Affiliated with the National Society of Professional Engineers

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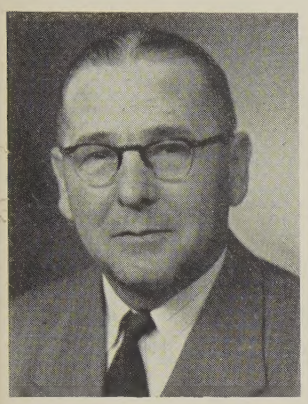
Of Interest to I. S. P. E.

PRESIDENT'S MESSAGE

Has the individual Professional Engineer and his chosen profession kept pace with the past 40 years of development in scientific research, engineering design, tooling and mass production?



PRESIDENT WALLACE

Are the members of our profession receiving their just credit for creating and making possible the modern day comforts of life, ease of travel, and last, the financial reward?

Only in the past several years has a small per cent of the public been aware of the fact that an "Engineer" does not always have his hand on the throttle of a locomotive, and does not necessarily perform some routine machine operation. Furthermore, the Professional Engineer need not wear high top boots and breeches and carry a transit to convince his client he is an Engineer. WHY?

Radio, T. V., newspapers and magazines are continually "throwing forward passes" to the public eye and ear by the statement "Engineered," and it is up to the Professional Engineering Societies to "carry the ball" over the goal line for the recognition they deserve.

Each Chapter should start now to make plans to participate 100% during "Engineers Week" and I know no better way to accomplish this than by making every week "Engineers Week."

I would like to suggest that each Chapter insist that their Publicity Committee cooperate with the local newspaper, radio and T. V. stations to provide items pertaining to the Professional Engineer and instead of waiting for John, why don't you make a determined effort to bring a guest to your next Chapter Meeting?

What's wrong with broadcasting to your friends and associates that you are a Professional Engineer?

The time is rapidly approaching when YOU must discard your high tops and adjust YOUR PROFESSION to the 1955 era, for it is later than some of you know or will admit.

It is better that you bargain in 1955 for a strong and unified Professional Organization by giving time, serious thought, cooperation and last but not least, your consideration for the Engineering Profession in the next 40 years.

DWAIN M. WALLACE, *President*

Somewhat overwhelmed by a eulogistic introduction, praising his charm and ability, the speaker faced the audience, pop-eyed and smiling eagerly. "Ladies and gentlemen," he said, "I can hardly wait to hear what I'm going to say."

OFFICIAL NOMINEES FOR 1956

During the past summer the corporate members of the Illinois Society amended the Illinois Society Constitution. Instead of voting on only two officers, the Constitution now provides that all officers of the Society be elected each year by vote of the corporate members. The official nominees presented by the Past Presidents Committee are:

President—Royce E. Johnson.

Vice President—Andrew W. Neureuther.

Secretary-Treasurer—A. Douglas Spicer.

National Directors—C. W. Klassen, Wayne W. Wallace.

Chairman Illinois Engineering Council Representatives—K. C. Hoeglund.

The above is in accordance with the requirement of the Illinois Society Constitution that the official nominees be announced in the *Illinois Engineer* not later than October 31st.

THE COVER PICTURE

If you owned Illiac, the given name of the digital computer which was designed and built by the staff of the University of Illinois, you probably would not need to know the answers to the professional engineering examination questions. This amazing machine can solve not only mathematical problems but it can also write the equation and draw the curve. For example, a diagram charting 200 points can be presented in seven seconds, a job that would take many hours when done by hand. Illiac "reads" punched teletype tape at the rate of two feet per second, which is 40 times faster than a teletypewriter operates. The College of Engineering makes frequent use of Illiac. Also using it are the Departments of Psychology, Chemistry, Physics, Economics, and Agriculture. The picture and data were supplied by Mr. Arthur Wildhagen, University of Illinois public relations department.

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READ THE ADVERTISEMENTS

SUBSCRIPTION RATES

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Items of Personal Interest

Vice President Royce Johnson made an extended business and pleasure trip to the West Coast after Labor Day. Mr. Johnson has a son in Syracuse University who is a Ph.D. scientist, another son is an M.D. and interning at Cook County Hospital in Chicago, and the third son is studying theology at Augustana Biblical Institute in Rock Island.

Central Illinois Auxiliary Unit number 1 has elected the following officers for the year to come: Mesdames Clarinda Hatfield, President; Juanita Auby, Vice President; Maxine Koeptz, Secretary; Marcella Schwalbe, Treasurer; Norene Gardner, Director. The ladies of the Auxiliary entertained the wives of those Board of Direction members who came to the October 1st meeting of the Board in Decatur.

Dr. Nathan M. Newmark, research professor of structural engineering at the University of Illinois, will become the head of the department of civil engineering on September 1, 1956. Dr. Newmark takes over the administration of the department which has been held by Professor Huntington for 29 years. Professor Huntington has been on the U. of I. faculty since 1914 and a member of the Illinois Society since 1926. He is retiring August 31, 1956, as he reached the magic age of 68 on September 29th this year. The best wishes of the Illinois Society for a long, successful administration to Dr. Newmark and a quiet, contented, happy retirement for Professor Huntington.

The professional and structural examination dates set for Fall of 1955 and 1956 are as follows:

Professional:
November 29 and 30, 1955
May 8 and 9, 1956
November 27 and 28, 1956.

Structural:
May 23, 24, and 25, 1956
Oral examination August 31, 1956
December 5, 6, and 7, 1956.

IS THIS A QUESTION OF ETHICS?

From Albuquerque, New Mexico, comes a story that is of particular interest to engineers. In May of this year the city engineer of Albuquerque accepted an all-expense airplane fishing trip to Mexico. The expenses of the trip were paid by two individuals, one of whom is a consulting engineer for Albuquerque and the other has been awarded a number of contracts with the city.

The acceptance was described as "unethical" by the chairman of the New Mexico State Board of Professional Engineers. The chairman pointed out that the engineers law allows revocation of license on the grounds of "gross negligence, incompetency or misconduct." The complaint demanding revocation was based on misconduct. The chairman pointed out that in his opinion there was unethical practice but that before a hearing could be held, evidence must be gathered to prove misconduct. It is admitted that there were no special favors granted or extended to the two who paid for the trip. Also, the city engineer was invited after another who planned to go had to cancel.

This question has undoubtedly arisen several times in Illinois. The *Illinois Engineer* invites you to express yourself on the above subject. Was it ethical or was it unethical for the city engineer to accept this kind of entertainment? Or just where is the line drawn on the entertainment of city engineers? Please sign your letters; however, if it is your desire to have your name withheld, that will be done.

An old crossroads merchant wrathfully wrote a debtor who had promised time and again to settle a long-delinquent account:

"You are just a mule-eared liar. If you don't settle up, I aim to clobber you until there won't be nothing left but a pair of suspenders and a wart. I want my money and I want it now."

He signed his name with a flourish, re-read the letter with grim satisfaction, then added the postscript, "Please excuse pencil."

Engineering Education at the Crossroads

By Herman L. Danforth

There is a growing awareness in the engineering profession of numerous areas where improvements must be made. The symptoms of basic trouble are well-known; it is not too clearly recognized that to get to the root of our troubles we must concentrate on correcting underlying causes rather than treating the symptoms. Let's look at some of the symptoms.

Compared to medicine and law, for example, engineering has a low and rather indefinite status in the minds of most people. The following illustration is a fairly typical example. We had recently moved into a new neighborhood. The next-door neighbor asked my wife, "What does your husband do?", to which she replied, with some pride, "He's an engineer." The response was a bit disillusioning, "Mine is, too; he digs ditches." Most professional engineers can recall similar experiences.

Then, too, at the time, the ditch-digging neighbor probably made more money. Much has been written on the subject of engineering salaries; little more need be added here. Is it any wonder that unionization looks attractive, particularly to young engineers?

We see much in the press regarding shortage of engineers. Is the shortage basically quantitative or is it qualitative? Are considerable numbers of engineers doing sub-professional work; if so, why?

But just what is the engineering profession, this apparently ailing patient of ours? It involves a body of knowledge so extensive that no one man can be thoroughly conversant with it all, hence the many branches and specialties. It involves the application of methods and procedures that have been found usable and useful. But essentially it is men—engineers. What these men do and how they do it—this is the very core of professional engineering. In turn, what the engineer does and how he does it is influenced to a large degree by the tools with which education provides him—basic skills and aptitudes, ability to think creatively, an understanding of the people and things about us with which he must deal. All of this plus assimilation of some portion of available, systemized engineering knowledge.

It seems apparent that to improve the engineering profession, we must start by improving engineering education. This is not to say that we don't have many fine engineering schools in this country, that there aren't many devoted and inspired individuals now teaching. With the vast increase in the body of organized knowledge, with the pressing need for more facilities and more teachers to accommodate greatly increased enrollment, with industry offering far more than professor's salaries for qualified men—our schools deserve the greatest credit for the work they are doing in the face of obstacles that must be overcome.

The point is that if the schools are to solve their immediate problems, the full help and cooperation of the engineering profession is needed. It is most important that we recognize, first, that the future of the engineering profession rests to a great degree on the improvement of engineering education, and second, that if significant improvements in education are to be made, the problem can't be left up to the educator alone. The active interest and cooperation of the professional engineer, individually and collectively, through his various professional organizations, is essential.

But good intentions and active assistance may do more harm than good unless there is a reasonably clear understanding of the problem and agreement as to objectives. This is where we must start if anything worthwhile is to be accomplished.

At the outset, the practicing professional engineer has an important contribution to make. He has a fairly good idea of what he expects and what he would like to see in an engineering graduate starting to work for him. We don't all look for the same things, particularly in the area of technical knowledge in some special branch of engineering, but there would seem to be a number of basic qualifications common to engineering in general. Such things as mathematical ability, not just knowledge of the techniques of manipulating figures, but a basic understanding of mathematical concepts; a firm grounding in the physical sciences, again a basic understanding of the materials and forces that make up the world around us and with which we must necessarily deal; and an ability to express one's self, if not fluently, then clearly and concisely. On the other hand, the extent to which we look for specialized technical knowledge is more questionable. We don't expect the newly hired graduate to know all the techniques and have the specialized knowledge to immediately perform in a proficient manner the jobs to which he may be intially assigned. But he may be expected to learn readily, and also to understand.

The first step, then, is to take a clear look at what we should expect in an engineering graduate, not so much in terms of his immediate value to an organization, but in terms of the qualities that have been developed that will affect his promotability—his future value, as an engineer, to the profession and to society.

After we take a clear look at the desired objectives, we should look next at the various dilemmas and problems with which the educators are faced. First, as mentioned before, there is the vastly expended amount of systemized engineering knowledge. Electrical and chemical engineering have evolved in the course of one lifetime from nothing to studies of great complexity. Civil engineering, of long relative stability of subject matter, has been broadened to include soil mechanics, prestressed concrete design and traffic studies. In all branches of engi-

neering new materials, new techniques, new knowledge are being added at a rapid rate.

Then there is the justified cry that the engineer must be a well-rounded individual; he must have enough of the "humanities"—history, literature, sociology, economics. From the educator's angle, the student's four precious years are jealously divided up, down to fractions of a per cent of available time. So much for humanities, so much for basic science, so much for strictly engineering subjects.

But a school is not just classrooms, curricula, laboratories; it is people. Looking back to college days, we are not as apt to remember courses or material taught as we are to remember particular professors or instructors. Particularly the infrequent one from whom we gained a clear insight into the behavior of materials and people, who provoked us into thinking and not just accepting. If engineering education is to improve, good men, great Teachers must be attracted to campuses in increasing numbers.

These are just a few of the problems besetting the educational institutions. To help solve them, all the help that we, as practicing professional engineers, can give is needed. It would be well to review the active part played by the American Medical Association and of the Bar Association in raising the professional status of doctors and lawyers respectively.

There are encouraging signs. The ASCE has an active Task Committee on Engineering Education. At a recent ASCE convention in St. Louis, an entire general session was devoted to the subject. It is evident that differences of opinion exist. This is a healthy situation, for out of it we are most apt to see new ideas, new areas of basic agreement, new methods whereby engineering graduates of the future may emerge better qualified to take their place among the ranks of truly professional engineers.

The Water Works Superintendent's little son, who was a TV fan, went to church with his mother. As they left, the pastor greeted them kindly and asked: "My little man, how did you like the service?"

"The singing was fine," the youngster answered honestly, "but you gave too long a commercial."

Obituary

Mr. Elmer A. Cavin, National Member and member of Lake County Chapter since 1946, died on September 11, 1955.

Mr. Cavin was born in St. Louis March 5, 1895, and was educated and spent the early days of his career in and around St. Louis. Immediately after World War I he became associated with the Division of Public Works of the Ninth Naval District at Great Lakes. He was in charge of the design division of the district which covers approximately 13 states. His division was responsible for the architecture and engineering for the roads, building, railroads, power plants, heating sewer, drainage and water systems of the Ninth Naval District.

He was registered in Illinois and an active member of Lake County Chapter.

WHAT IS FAITH?

Faith is not trying to believe something regardless of the evidence. Faith is daring to do something regardless of the consequences.—Sherwood Eddy.

Definition of a father: An older man who tries to scare away younger men not good enough for his daughters, and later spends most of his time bragging about his grandchildren being smarter than anyone else's.

Typical Questions

Taken from Examinations given by the State of Illinois Department of Registration and Education during 1953 and 1954.

Foreword

VERA M. BINKS
Director Department of Registration and Education
August, 1955.

Three years have passed since the Department of Registration and Education last made public sample questions taken from examinations given by the Department to applicants for registration as Professional Engineers in the State of Illinois.

During this period the Illinois Professional Engineers Examining Committee has devoted much time to a study of examination questions and procedures and has continued its cooperation with the Committee on Written Examinations of the National Council of State Boards of Engineering Examiners.

In order to acquaint members of the engineering profession in the State with the character of the examinations set for applicants for registration the Department released for publication examinations used in November 1946, November 1948, May 1949 and December 1949. In July 1952 the Department released for publication a series of typical questions taken from examinations used during 1950, 1951 and 1952. These examinations and typical questions were published jointly by the Illinois Society of Professional Engineers and the University of Illinois Extension Division and used to assist candidates preparing for registration examinations.

At this time the Department is releasing for publication by the same organizations a series of typical questions taken from examinations given during 1952, 1953 and 1954.

It is not now the policy of the Department to publish complete examinations and it is to be understood that the questions released at this time are merely for the purpose of indicating the type of questions used on recent examinations and do not in any sense constitute a complete examination.

FIRST DAY

(Enrollment of Engineers-in-Training)

Morning

1. Find the area bounded by the parabolas $y = x^2 - 2x$ and $y = 6x - x^2$.

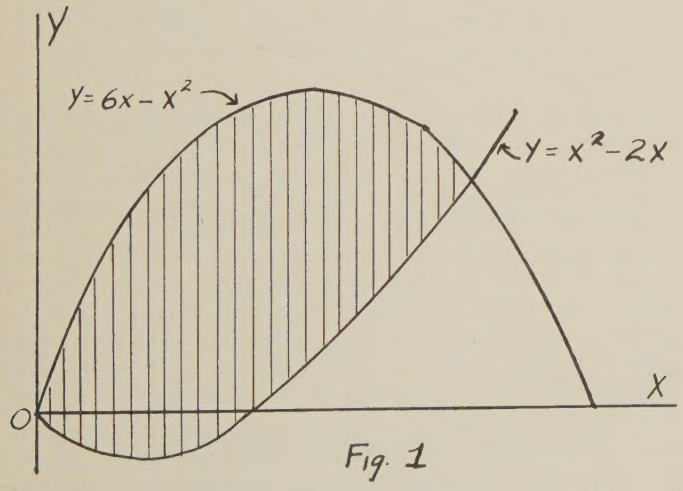


Fig. 1

2. Given the curve: $y = e^{1/2x} - 2x^2$
   (a) Calculate the value of y at $x = 10$.
   (b) Calculate the values of x and y at the point where the tangent to the curve is horizontal.

3. (a) A sheet of metal is 24 inches by 36 inches. It is desired to remove a uniform (in width) border from the metal to obtain a smaller sheet with an area of 400 sq. inches. What must be the width of the border?
   (b) Suppose that we wish to make a pan of maximum capacity from the 24 in. by 36 in. sheet. We will do this by cutting squares from each corner, then turning up the edges to form a pan. What must be the size of the squares?

4. It is necessary to weigh an object accurately on a beam balance that is known to be slightly inaccurate. When placed in the left pan the object is found to weigh 8.96 grams and when placed in the right pan, it is found to weigh 9.06 grams. If the inaccuracy in the balance is due solely to lack of precision in the lengths of the arms, what is the true weight of the object?

5. Figure 2 shows the circuit of a Wheatstone bridge. Describe how you would adjust it to determine the unknown resistance, R_x. If, when so adjusted, $R_s = 20$ ohms, what is the value of R_x?

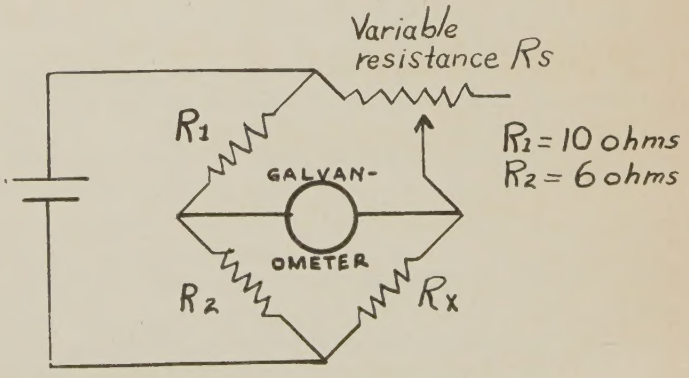


Fig. 2

6. In a rocket motor fueled with butane, C_4H_{10}, how many kilograms of liquid oxygen should be provided with each kilogram of butane to provide for instantaneously complete combustion?

$$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$$

Atomic weights

C 12.0 H 1.0 O 16.0

7. A cylindrical tank is to contain 1125 cu. ft. and is to have a flat bottom and a hemispherical screen for a roof. The bottom cost 40 cents per square foot, the curved wall 30 cents per square foot and the roof 20 cents per square foot. Find:

(a) The proportions of the tank so that the cost of materials will be a minimum.

(b) The cost.

8. A driver traveling 55 miles per hour sees a stop light. If it takes him 0.6 seconds to apply the brakes, and the brakes give a deceleration of 15 ft./sec.^{2}, how many feet does he travel before coming to a stop?

9. A mass of copper, suspected of being hollow, weighs 523 grams in air and 447.5 grams in water. What is the volume of the cavity? The specific gravity of copper is 8.92.

10. Calculate the heat content (above 0 C.) of 15 kg. of tin as (a) solid tin just at the melting point, (b) molten just at the melting point, and (c) at 1200 C.

The melting point of tin is 232 C.

The specific heat of solid tin is $(0.0534 + 0.0000174t)$ Cal/gm.

The specific heat of molten tin is 0.55 Cal/gm.

The latent heat of fusion is 14.5 Cal/gm.

11. In Figure 3, the surface AB is horizontal, the surfaces BC and CD are parabolic with the common tangent at C, the surface DE is vertical and the surface EF is horizontal. The tangents to the parabolic surfaces BC and CD are horizontal at B and D respectively. Neglect friction and air resistance losses and calculate:

(a) The velocity at which a 20-lb. ball rolling to the right will have to pass the point B so that it will remain in contact with but exert no pressure on surface BC.

(b) The distance from E that it will strike the surface EF.

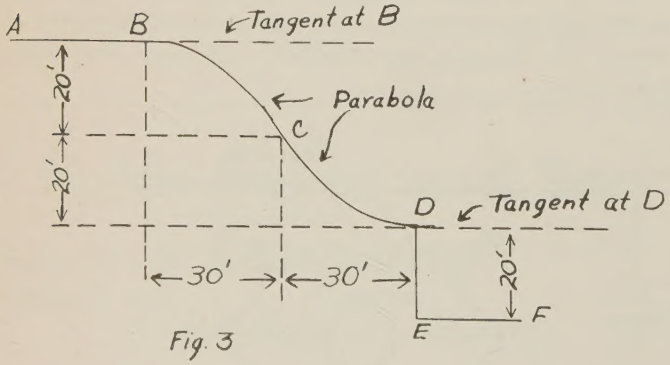


Fig. 3

12. A 200-watt incandescent lamp is connected to a 120-volt source.

(a) What current will be drawn by the lamp?

(b) What is the resistance of the lamp when operating?

(c) When cold, will the resistance of the lamp be greater or less than when operating?

FIRST DAY

Afternoon

1. A rectangular simple beam is 8 inches wide and 12 inches deep. It carries a uniformly distributed load of 600 lb. per ft. and a concentrated load of 1000 lb. applied at a section 6 ft. from the left end. Find the maximum bending unit stress in the beam. Span is 20 ft.

2. A gear-head motor runs at 1728 r.p.m. and has an output of 1½ horsepower through a double gear reduction of 3 to 1 ratio per step. Motor efficiency is 75%. Each gear reduction has 3% friction loss. Calculate:

(a) Overall efficiency.

(b) Output torque.

(c) Watts input.

3. One mole of gas occupies 22.4 liters at 0° C. and 1 atmosphere.

(a) What pressure would be required to compress 1 mole of oxygen into a 5 liter container held at 100° C.?

(b) What maximum centigrade temperature would be permitted to hold this mass of oxygen in 5 liters if the pressure is not to exceed 3 atmospheres?

(c) What capacity would be required to hold the same mass if the conditions of 100° C. and three atmospheres were fixed? Molecular weight of $O_2 = 32$.

4. A homogeneous ladder 18 ft. long and weighing 120 lb. rests against a smooth wall. The angle between it and the floor is 70°. The coefficient of friction between the floor and the ladder is ¼. How far up the ladder can a 180-lb. man walk before the ladder slips?

5. An electric truck is propelled by a d-c motor drive connected to a 110-volt storage battery. The truck is required to exert a tractive effort of 200 pounds at a speed of 5 miles per hour. If the overall efficiency of motor and drive is 70%, what is the current taken from the battery?

6. A jet of water 2 inches in diameter exerts a force of 300 lb. on a flat vane perpendicular to the stream. What is the nozzle velocity of the jet?

7. During tests of a 3¼ by 4¼, six-cylinder automobile engine at full throttle, the following data were secured: work output of engine 100 h.p., speed 3000 r.p.m., temperature of room 90° F., barometer 29.92 inches of mercury, temperature of incoming cooling water 150° F., temperature of outgoing cooling water 165° F., weight of cooling water circulated 200 pounds per minute, weight of air supplied 15.1 pounds per pound of fuel, heating value of fuel 20,000 Btu per pound, 36 pounds of fuel burned per hour, temperature of exhaust gases 1300° F., friction work (including fluid friction) 15 horsepower, compression ratio 6. Make an energy balance based on Btu per minute.

8. A body at rest 165 feet above sea levels weighs 100 lbs.

(a) What potential energy has the body with respect to sea level?

(b) What work against gravity was required to raise the body from sea level?

(c) If the body were raised the 165 feet in 30 seconds, what horsepower was expended?

(d) If the body should fall from its present position, what would be its kinetic energy on reaching sea level?

(e) What would be the body's momentum on reaching sea level?

9. Draw the shear and moment diagram for the beam shown in Figure 4 approximately to scale and calculate the controlling ordinates. Consider only loads shown.

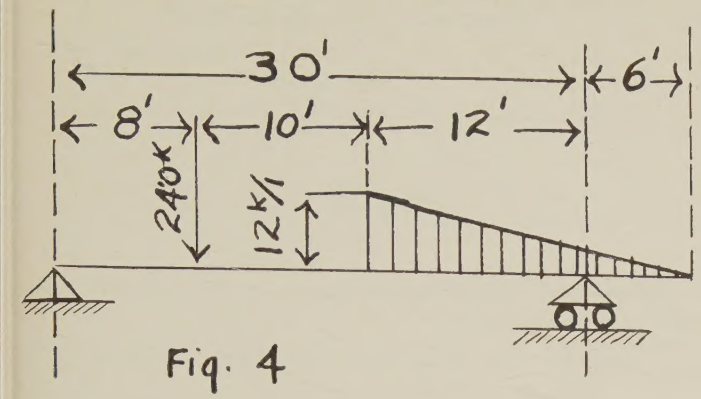


Fig. 4

10. Air at a pressure of 29.92 inches of mercury absolute and 90° F. dry bulb temperature has a relative humidity of 50%. Find:

(a) The partial pressures of the dry air and the water vapor.

(b) The dew point.

(c) The humidity ratio.

(d) The volume of mixture per pound of dry air.

11. Find the stresses in the members of the derrick shown in the accompanying figure, No. 5, due to the 10,000-lb. load.

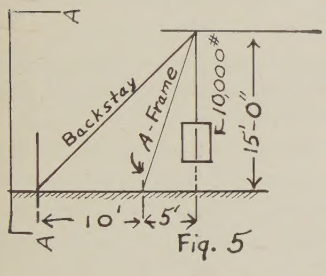
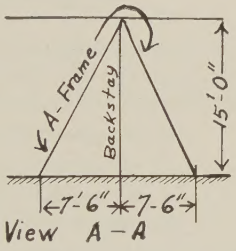


Fig. 5



View A – A

12. The beam shown in the diagram (Fig. 6) has a cross section 4" x 6" actual size with the 6" used as the depth.

(a) Calculate the reactions.

(b) Sketch and dimension a shear and bending moment diagram.

(c) Calculate the maximum compressive unit stress in the beam.

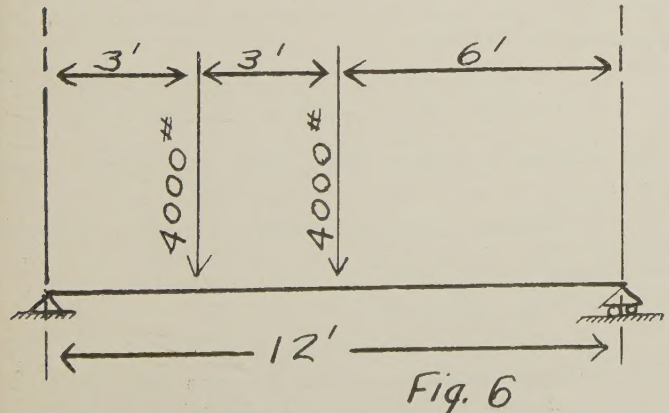


Fig. 6

13. Compressed air is to be stored in tanks 18 inches in diameter and 12 ft. long. The maximum pressure at 130° F. must not exceed 1500 lb. gauge. What weight of air can be stored in each tank? What would be its volume before compression if the barometer reads 29.6 and the thermometer 40° F.?

14. A body is moving in a straight line according to the law,

$$s = \tfrac{1}{4}t^4 - 2t^3 + 4t^2$$

Find its velocity formula. Its acceleration formula. When is its velocity a maximum? During what interval is it moving backward?

SECOND DAY

Morning

1. (a) Calculate the density of air with a dry bulb temperature of 75° F., relative humidity of 50% and a barometric pressure of 29.0 in. Hg., and the pounds of moisture per lb. of dry air. Do not take the answers from psychrometric charts.

(b) Five thousand cu. ft. of air per minute flow through a duct. The air is at 70° F. dry bulb and 60° F. wet-bulb. It is desired to reduce the relative humidity to 45% by passing the air over an absorption agent. Find the weight of water removed in pounds per minute.

2. A farmer wishes to have exactly one acre surveyed off in the northwest corner of the northwest quarter of section 6, T8N—R8E—4PM. The dimension along the north line is to be 200 feet and the opposite sides to be parallel.

Compute the other dimensions and write the description assuming that the west line runs north and south.

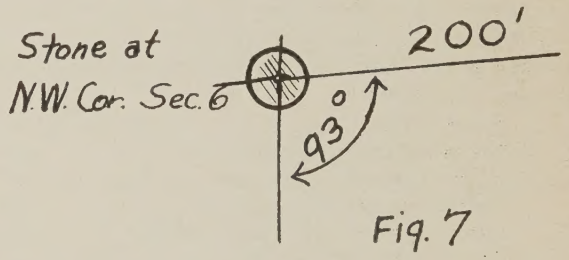


Fig. 7

3. A 22,000-volt, 50,000 kva 0.8 power factor 3-phase smooth-rotor synchronous generator generates in parallel with other 3-phase generators at a constant terminal voltage of 22,000 volts. The generator has a synchronous reactance x_s of 1.00 per unit.

The resistance of the armature is negligible. Just after this generator is connected to the 22,000-volt bus the prime mover is adjusted so that the real power is zero and the field excitation is adjusted so that the generator supplies 25,000 kva reactive (current lagging). Later the input to the prime mover is adjusted, without changing the field excitation, so that the real power supplied by the generator is 40,000 kw. Determine the reactive power and power factor when the generator delivers 40,000 kw with this last adjustment.

4. A milling machine is to be designed to use a cutter 4 inches in diameter and 6 inches wide, and is to be capable of a feed of .050 inches per revolution at a depth of cut of ⅜ inch and a cutter peripheral speed of 200 sfm. The material to be machined will require approximately 0.5 h.p. per cubic inch at the cutter, and the efficiency of the cutter drive is 60%. What size drive motor should be used on this machine? (standard commercial horsepower rating).

The table of this machine is to weigh 5000 pounds, including fixture and work, and it is desired to rapid traverse it upward at 600 inches per minute. Assuming 50% for friction, will the drive motor be suitable for rapid traverse?

5. A vertical furnace wall is made up of an inner wall of magnesite brick 9 in. thick followed by an outer wall of kaolin insulating brick 4.5 inches thick. The magnesite brick has a density of 158 lb. per cu. ft. and a thermal conductivity $k_1 = 2.2$ at 400° F. and 1.1 at 2200° F. The kaolin brick has a density of 27 lbs. per cu. ft. and a thermal conductivity $k_2 = 0.15$ at 900° F. and 0.27 at 2100° F. These conductivities may be assumed to vary linearly with the temperature. If the temperature of the inner surface of the magnesite is 2200° F. and the outer surface of the kaolin is 300° F. what is the heat loss through the wall in Btu per hr. per sq. ft. and what is the temperature of the contact surface of the two materials? (Contact resistance may be neglected.)

6. Two 8″ sewers enter a manhole at invert elevations of 101.31 and 100.98 respectively. The first is designed to carry 0.7 cfs and the second 1.5 cfs. The minimum velocity permitted in the outlet line is 2 feet per second. For all sewers, $n = 0.015$.

(a) What is the minimum grade which can be used for the outlet line?
(b) What is its size?
(c) What is the velocity of flow in the outlet line?
(c) What is the correct invert elevation of the outlet line at the manhole?

7. A resistance-capacitance coupled vacuum tube Class A amplifier employs a triode with an amplification factor of 20 and a plate resistance of 10,000 ohms. The grid resistance of the succeeding stage is one megohm.

What values of load resistance and coupling capacitance will provide a voltage gain of 15 in the middle frequency range and a lower half-power frequency of 30 cycles per second?

8. A steam generating unit, comprising furnace, boiler, superheater and air heater, is designed to operate at the following peak conditions:

Steam output	600,000 lbs. per hr.
Feedwater temperature	420° F.
Drum pressure	1,027 psi
Pressure at superheater outlet	935 psi
Temperature at superheater outlet	950° F.
Overall efficiency of unit	85.5%
Furnace heat release	17,600 Btu per cu. ft. per hr.
Heating value of coal as fired	10,400 Btu per lb.

(a) What is furnace volume?
(b) What is coal consumption in pounds per hour?

9. A compressor takes gas of specific gravity = 0.65 and .01 centipoises at conditions of flow, 80° F., compresses it isothermally and delivers it at 50 lb./inch² gage through 1000 feet of 6-inch line at 2000 cubic feet/minute (measured at 60% F and 1 atmosphere pressure). Determine the theoretical h.p. of the compressor. Intake pressure, atmospheric.

10. A downgrade of 1.75% intersects an upgrade of 2.25% at an elevation of 578.00 at station 38 + 60. Compute the grade for each even 50-ft. station for a 500-ft. vertical curve. Show computations.

11. A telephone line is employed to transmit a signal from source A to load B as shown in the figure. The line is represented by the "T" network shown. It is found, however, that the line introduces more loss than is desired. It is suggested that a second identical line be connected in parallel with the first (at a, b, c) to reduce the loss.

(a) Will such an arrangement deliver more power to load B?
(b) Discuss the reasons for your answer in (a).

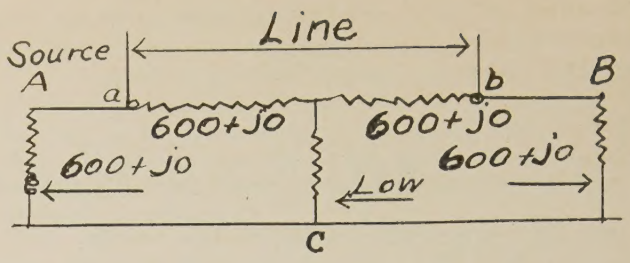


Fig. 8

12. The PGR Steel Company has the following safety record for the past six months:

One man lost first finger, right hand. He returned to work in 20 weeks.
One man cut hand and missed 5 working days.
One man was killed.
One man smashed foot and missed 12 weeks work.
One man got a steel splinter in eye and missed 4 hours work (8 a. m. to 12 noon).

The Company worked 5 days a week for 24 weeks in the past 6 months, eight hours per day. There were 1000 men in the plant during this period.

Wanted:

(a) What was the severity rate?
(b) What was the frequency rate?
(c) What was this: a relatively safe or unsafe plant? Explain your answer.

13. On a certain rotary rig with a five-sheave crown block and a four-sheave traveling block, the weight of the drill stem and blocks is estimated at 100,000 pounds.

(a) If, when coming off bottom, the driller accelerates at the rate of 2′ per second per second, what is the stress in the deadline, neglecting friction losses?
(b) What horsepower would have to be delivered to the traveling blocks?

14. A small store has a total heat gain from all sources, except outdoor air, of 67,500 Btu per hr. The latent heat portion of the above is 14,400 Btu per hr. Required indoor air state is to be 75° F. dry bulb and 50% relative humidity. The outdoor air state is 91° F. dry bulb and 73° F. wet bulb. 1200 cfm outdoor air is supplied to the system and mixed with a part of the recirculated air. This mixture then passes through an air washer having an apparatus dew point of 50.5° F. A part of the recirculated air (by-passed air) mixes with the air leaving the washer and the resulting mixture enters the fan which supplies air to the room at a temperature of 61° F. Neglect energy of the fan.

(a) Determine the amount of refrigeration required.
(b) Determine the volume of by-passed air in cfm.

15. A 5-inch centrifugal pump shows the following performance:

Discharge, cold fresh water, 1.30 cu. ft. per sec.
Speed, 1600 r.p.m
Shaft input, 18 h.p.
Total head, 75 ft.

(a) What is the efficiency of the pump?
(b) If the efficiency remains the same while the speed changes to 1000 r.p.m., what should be the head?

16. Given a full-wave rectifier using a center-tapped transformer delivering 500 volts rms on each side of the center tap. This rectifier operates from a 60 cps power line and feeds a filter consisting of an 8 henry series inductance followed by a capacitance C across the output. (Assume the tubes and transformer to be lossless.)

(a) If the inductance has a d-c resistance of 200 ohms, find the d-c output voltage available from the rectifier combination if the d-c load current is 200 ma.

(b) Find the capacitance required for the output capacitor such that the r.m.s. value of the 120 cps component of the filter output voltage will be reduced to ten volts.

17. Outline the fire protection measures that should be followed to prevent loss in a large production machine shop. Name the construction, material selection and design features as well as the special devices that should be provided for this protection and the reason for each.

SECOND DAY

Afternoon

1. Because of foundation costs and flood conditions, it is desirable to locate a new steam power plant at as high an elevation as possible on a selected site. However, this arrangement involves the maximum pumping head for condensing water from the nearby river.

Average full load condensing water requirement is 50,000 g.p.m., handled by motor-driven centrifugal pumps. Pump efficiency 80%; motor efficiency 92%.

Annual plant capacity factor 70%.

Cost of power for pumping, .5 cents per kwh.

How much can you afford to spend over and above minimum cost of foundations in order to reduce average pumping head by 20 ft.? Capitalize annual costs on 10% basis.

2. A company leased a parking lot site from a city and prepaid the rental for five years. The terms of the lease provide that the company may continue to rent the site for an additional five years by paying $5,000 at the beginning of each year of the second five-year period. One year of the prepaid period has expired and the city is in need of funds. The city proposes to the company that it prepay the rental which was to have been paid year by year in the second five-year period. If interest is 3% per year, what payment now would the parking lot company have to make in lieu of the five annual payments?

3. How much more could be paid for a hydroelectric power plant and transmission line than for a steam plant, to be run at full load for 3000 hours per year, if the operating costs for the latter are 0.6 cents per horsepower hour, while for the hydroelectric system they are only 0.2 cents per horsepower hour? Assume the life in either case to be 30 years and interest to be 5%, while all other things are equal.

4. Engineers are frequently asked, "What is it worth?" As an example, an engineer for a mining company is directed to examine a special property and advise the company as to its probable value. The engineer estimates the ore readily available to be 880,000 tons and bases his evaluation on that figure.

Mining facilities available will remove about 55,000 tons of ore per year. It is estimated that mining operations, transportation and smelting costs will total $5.75 per ton of ore, and that the gross income will be $11.75 per ton of mined ore. Administrative and other expenses are estimated to be $30,000 per year.

What should the engineer report as the probable value of the mine if it is to return the investment and yield annual income return of 6% on the investment throughout its life?

5. A sinking fund bond is to be issued for a $10,000 municipal improvement. The interest rate is 4% and the bond is to run for 10 years.

(a) If the sinking fund is invested at 3%, what will be the annual tax and the total cost?

(b) If the sinking fund were not invested, what would be the cost?

6. Calculate the theoretical maximum temperature of water gas (50% H_2 and 50% CO by volume) when burned with 50% excess air, all of the air being preheated to 800° C. Show all calculations.

7. With the alignment information given in Figure 9, determine all curve data and compute deflection angles necessary to stake out curve, using railroad or highway curve tables and 25′ chord lengths.

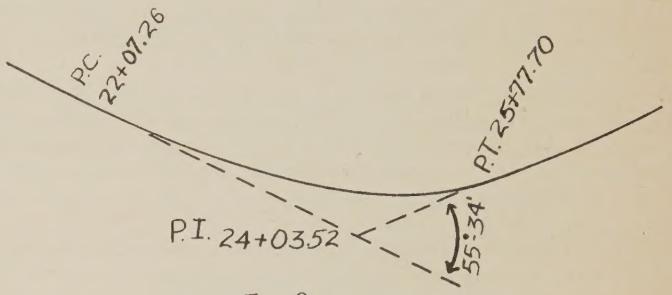


Fig. 9

8. An industrial power load of 2700 kw at 0.9 power factor is to be supplied over a 60-cycle three-phase power line 10 miles long. Assume that duplicate supply is not justified and that the load is not expected to increase.

(a) Choose an appropriate standard operating voltage and copper conductor size to limit the full-load line regulation to 5%. Approximate formulas for voltage regulation are sufficiently accurate.

(b) Describe the basis for the choice and calculate the full load line loss.

(c) State the equivalent conductor spacing used and sketch the conductor arrangement assumed.

(d) In view of the conditions stated, outline very briefly what other practical considerations might affect the physical and electrical design of the line.

9. Sketch an ammonia compression refrigeration system naming each of the fundamental elements. Brief the specifications for a 100-ton installation to be used for the manufacture of ice, sizing each element for an installation having a 440-volt, 3-phase electric power supply and an ample supply of cooling water not exceeding 80° F.

10. A crude-oil pipeline is carrying 6000 bbl. (42 gal. each) of crude oil daily through 27 miles of single pipe, 12 in. ID. This capacity is now insufficient to meet the consumer's requirements. Accordingly, a parallel branch of the same size, extending for one-third of the total distance is to be added. How much has the capacity of the pipe line been increased by the addition of the parallel branch if the line is level throughout, the oil has a specific gravity of 0.91 and a viscosity at flowing temperature of 500 centipoises, and the same pressure is maintained at the inlet of the pipe line?

11. (a) For what capacity in cfs should the main sewer of a city of 30,000 population be designed, the water consumption being 90 gallons per capita per day. Ignore all other factors.
(b) Determine the size of the sewer using a slope of 0.002 (0.20%), a peak flow of twice the average flow, and provide for the sewer to run one-half full at peak flow.

12. A non-inductive resistance of 50 ohms is in series with a condenser of 45 micro farads, across a 125-volt, 60-cycle supply.
(a) What current will flow?
(b) What is the voltage across the resistance and the condenser?
(c) What is the total impedance of the circuit?
(d) What is the capacity reactance and the resistance for the entire circuit?

13. On a test run of a double acting 8 x 12 inch simple engine, operating at 190 r.p.m., the following observations were made:
Indicator cards 3 inches long, using a 100-lb. spring, have areas of 1.3 square inches for the head end, and 1.24 square inches for the crank end. The diameter of the piston rod is 1.5 inches.
The brake arm is 60 inches long, with a net load of 78 lbs.
Steam was supplied for the test at the rate of 700 lbs. per hour, at 140 psi and 98% quality. The engine exhausts to atmosphere, and the barometer reading was 29.8 inches. Find:
(a) The indicated horsepower.
(b) The brake horsepower.
(c) The friction horsepower.
(d) The mechanical efficiency.
(e) The indicated thermal efficiency.
(f) The brake thermal efficiency.

14. List the unit operations of chemical engineering. List the unit processes of chemical engineering. Describe each unit operation or unit process in not over three lines and a sketch (if the latter will help). Note the unit processes which obtain in three of the following industries or branches of engineering:
(a) Ceramics industry.
(b) Rubber tire manufacture.
(c) Aircraft maintenance.
(d) Sanitary engineering.
(e) Pulp and paper industry.
(f) Lumber industry.
(g) Bakeries.

15. A community of 800 persons, located in a hilly region, wishes to build an elevated water tank that will hold a 72-hr. supply. The per capita use of water is 80 gallons per day. Customers must be served at elevations ranging from 527 ft. to 640 ft. The site at which the tank is to be erected is at Elevation 630. All customers must at all times be provided with a static head of at least 35 pounds per square inch. The static head for any customer must not exceed 100 pounds per square inch at any time.
(a) What is the capacity of the required tank?
(b) How high above the ground at the site of the tank must the overflow be located?
(c) What is the minimum elevation to which the water may be permitted to fall in the tank?
(d) What is the diameter of the required cylindrical tank?

16.

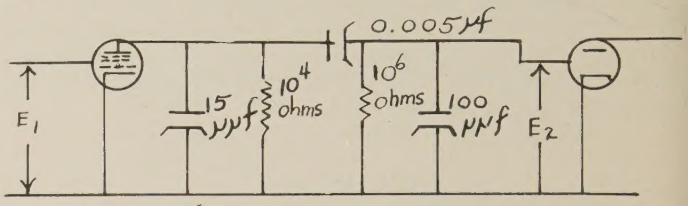


Fig. 10

The above circuit is the equivalent a-c circuit diagram of a resistance-capacitance coupled amplifier stage including all effects of the following stage.
(a) What is the maximum value of the voltage gain, E_2/E_1?
(b) What is the lower frequency at which the gain drops to 0.707 of its maximum value?
(c) What is the upper frequency at which the gain drops to 0.707 of its maximum value?

17. Describe the operation of a hydraulic coupling and sketch the fundamental elements. List three advantages and three limitations of this type of coupling.
Name two accessories often found with couplings designed for use in automobiles.

18. Water is entering a salt water pit through a 2″ I.D. pipe, the end of which is 4′ above the level of the pit. The pipe is flowing full and the center of the stream strikes the surface of the water 2′ horizontally from the end of the pipe. Neglect air losses.
(a) How many barrels per day are entering the pit?
(b) If the water is 1.05 S.G. and is moved out of the pit by a centrifugal pump with a 6″ discharge operating against 150 psi, at 70% efficiency, what BHP will be required of the prime mover if the pump is 5′ above pit level?

PROFESSIONAL DIRECTORY

I hold every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and ornament thereunto.

Sir Francis Bacon

COST OF LIVING INDEX

The cost of living correction factor to be applied to the I.S.P.E. Schedule of Minimum Fees and Salaries is based upon the Consumer Price Index of the 1947-49 average as determined by the Bureau of Labor Statistics. On the 1947-49 base the correction factor for August, 1955, is 114.5.

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Development. Des. Engr., Mech. or Elect. Age: 30-plus. 3 plus yrs. exp. in elect. and mech. develop. and des. of fractional hp. motors. Know: Electronics desired. Duties: design—dev. and appl. of fractional hp. motors, on both elect. and mech. features. Should have ability to work without supv. U. S. Citizen. For Assembler of electronic eqpt. Sal.: $7-8000. Loc.: Chicago. Employer will negotiate the fee. C-3842

Chemical Engineer. B.S. Age: Up to 35. 1 plus yrs. exp. in pilot plant operations. Know: High polymers. Duties: Resp. of running pilot plant producing synthetic rubbers and latex and improving production processes. For mfg. of Rubber. Sal.: $400-550. Loc.: Ohio. C-3839

Res. Engr. Grad. Arch. or Struct. Age: 30-40. 5 plus yrs. exp. grad. res. or indus. dev. Duties: staff position will lead to full resp. for the struct. engrg. res. conception, invention des., invest. and field erection of clay, brick, and tile bldg. assemblages are the core of the work. For ox. prestressed claytile interior partitions, panels are being dev. Lab. invest. incl. analytical analysis as well as experimental work on specimens ranging to full size. Will direct supv. of lab. tech. and eqpt. Must have good analytical ability and to work with hands is nec. Adjunct to well-rounded ability in this type of research. Able to record experimental finding statistically desired. Sal.: About $8400. Loc.: Fox River Valley. Employer will negotiate the fee. C-3838

E.E., I.E., or M.E. 2 yrs. exp. light mfgrg. particularly where female employees are involved. Know: Production of small components. Duties: Dev. of new process, trouble shooting on an operation that is not running smoothly, setting up standard practices and procedures and instructing and orienting new personnel. For a Mfgr. of Electr. components. Sal.: to $125.00. Loc.: No. Shore Suburb. Employer will negotiate the fee. C-3835

Devel. Engr. E.E. or equiv. Working familiarity with elect. or electronic component required. Duties: Plan and carry out details of a dev. or test program related to constr., testing or dev. of electrical and electronic components or apparatus. For Mfgr. of Elect. components. Sal.: to $125.00. Loc.: No. Shore suburb. Employer will negotiate the fee. C-3834

Physicist—solid state. Degree in physics. Exp. with growth of silicon crystals and use for transisters. Duties: Res. and product dev. in the field of semi-conductors and semiconductor devices. For Mfgr. of elect. components. Sal.: $800-$10,000. Loc.: No. Shore Suburb. Employer will negotiate the fee. C-3833

Statistical Quality Control. Age: 25-40. 3 plus yrs. exp. in statistical quality control in metals industry using charting and sampling. Know: multiple correlation. Duties: doing statistical quality control work using control charts, sampling, multiple correlation and analysis of experimental data. For Mfr. of metals. Sal.: Open. Loc.: California. C-3828

Coord. of Mgmt. Serv. M.S. or Ph.D. Age: 33-43. 6 plus yrs. exp. in mgmt. dev. and appraisal, testing, personnel, res., training, recruitment and selection. Duties: in connection with corp. mgmt. inventory and dev. program. Also mgmt. recruitment and selection, organization charts, college recruitment, and statistical and other studies. For Mfr. of Met. and Chem. Sal.: Open. Loc.: California. C-3827

Mfg. Exec. M.E. Age: 44-48. 5 plus yrs. exp. in fabrication of food, dairy, or liquid machy. as plt. mgr. or wks. mgr. Know: Fabr. light gauge stainless steel. Duties: resp. for manuf. light machy. and eqpt. for food, dairy, or bottling industries. For Mfr. of light machy. Sal.: $12,000-$14,000. Loc.: Iowa. Employer will neg. fee. C-3823

Sales Promotion Mgr. Age: 44-48. 5 plus yrs. exp. supervising and directing sales dept. of sales promotional activities. Know: food industry and stainless steel. Duties: Resp. for directing dept. of about 20 people in sales and sales promotional work on light, automatic, machinery and allied eqpt. sold to food, dairy, and bottling industries. For Mfr. of light machy. Sal.: $12,000-14,000. Loc.: Iowa. Employer will negotiate fee. C-3822